WeatherMan: A Utility for Managing and Generating Daily Weather Data

N. B. Pickering,* J. W. Hansen, J. W. Jones, C. M. Wells, V. K. Chan, and D. C. Godwin

ABSTRACT

Daily weather data commonly used in simulation models of agricultural or ecological systems are sometimes incomplete, frequently contain errors, and are often in an inconvenient format. The WeatherMan is a user-oriented software package designed to assist in preparing daily weather data for use with simulation models. The software can import or export daily weather files with any column format (including the Decision Support System for Agrotechnology Transfer ver. 2.1 and ver. 3.0 files) and convert the data to desirable units. Data are checked and flagged for possible errors on import. Several techniques are available for filling in missing values and erroneous data on export. WeatherMan also contains two methods (WGEN and SIMMETEO) for stochastically generating sequences of daily weather data. Both methods can be parameterized from the daily data and the second method uses monthly means from any secondary data source. Summary statistics of raw and generated data can be graphed or presented in tables.

DAILY WEATHER DATA are commonly needed for input to simulation models used in agricultural or ecological systems. While the models require complete and reliable values in a particular format, the raw data from a weather station, or even a reliable secondary supplier of weather data, seldom meet these requirements. Common data problems include: data format errors resulting from alphabetic characters, missing data, data suspected to be erroneous, and data in an inconvenient format. Sometimes there are no data available for a specific site, and commonly not all the desired variables are in the available weather record. Data errors usually result from sensor and/or datalogger failure or sensor calibration drift.

The development of crop models and decision tools such as the DSSAT (Decision Support System for Agrotechnology Transfer) to aid research and development in agriculture has been the focus of the IBSNAT (International Benchmark Site Network for Agrotechnology Transfer) project (IBSNAT, 1989). Available and reliable weather data are essential to make reasonably good predictions of crop growth and production using these models. The IBSNAT project has defined a minimum daily weather data set and format for use with the crop models. In the minimum data set defined for IBSNAT ver. 2.1 (IBSNAT, 1989), the daily variables are solar radiation (MJ m^{-2} d^{-1}), maximum temperature (°C), minimum temperature (°C), rainfall (mm), and photosynthetically active radiation (PAR, mol m^{-2} d^{-1}) (if available). The IBSNAT ver. 3.0 data set (Jones et al., 1993) has a different format, but uses the same variables, as well as dew point (°C) and wind speed (m s^{-1}) if available. An example of the file formats is given in Table 1.

The goal of the WeatherMan software is to provide the necessary tools to archive, summarize, and manipulate weather data into any convenient format. Previous efforts to create weather databases (AWDN/AGNET, CIRIS, DSSAT ver. 2.1) used relational databases to manage fixed-format weather data usually collected by a state network of automated weather stations (Hubbard et al., 1983; Snyder et al., 1985; Carlson and Russell, 1988; IBSNAT, 1989; Reinke and Taylor, 1991). Desired daily data or summaries were exported to ASCII files. Other efforts (AZMET) provide current 2-wk weather data summaries and evapotranspiration estimates on a computer bulletin board (Brown and Yitayew, 1988). Only Robbins (1993) has developed generic routines to read self-describing, random-access, weather-data files in any format. There is currently no system to easily read and write weather data files in any format, provide techniques for replacing erroneous data or generating data, and provide summary graphs and tables.

PROGRAM DESCRIPTION

The WeatherMan (short for weather data manager) program is designed to simplify or automate many of the repetitive tasks associated with preparing raw weather data for use by a crop model (or any other model) and can also be used to provide quantitative analysis of weather data. WeatherMan specifically handles the IBSNAT ver. 3.0 variables, but other daily weather variables can also be added. It can be used either as a stand-alone package or from within DSSAT ver. 3.0. WeatherMan has the ability to translate both the format and units of weather data files, check for errors on import, and fill in missing or suspicious values on export. WeatherMan can also generate complete sets of weather data comprising solar radiation, maximum and minimum temperature, rainfall, and photosynthetically active radiation. Summary statistics of raw, filled, or generated data can be computed and displayed in tables or graphs.

Specifications

WeatherMan is written in Turbo Pascal ver. 7 (Borland, 1993) and uses royalty-free graphics routines (Quinn-Curtis, 1993). The object-oriented utilities in Turbo Pascal's Turbo Vision were used to create a text-mode user interface for WeatherMan that includes: pull-down menus; dialog boxes with push buttons, radio buttons, check boxes, input lines, scrolling dynamic lists, and context-sensitive help. The WeatherMan interface functions both with the mouse and the keyboard.

WeatherMan will work on an IBM-compatible micro-

N.B. Pickering, J.W. Hansen, and J.W. Jones, Agric. Eng. Dep., Univ. of Florida, Gainesville, FL 32611; C.M. Wells, Dep. of Agric. Eng., Massey Univ., Private Bag, Palmerston North, New Zealand; V.K. Chan (formerly IBSNAT Project), Long Distance/USA Sprint, 925 Dillingham Blvd., Honolulu, HI 96817; and D.C. Godwin (formerly Int. Fertilizer Development Ctr., Muscle Shoals, AL), Alton Park, MS 2, Dubbo, NSW 2830, Australia. Contribution from the Florida Inst. of Food and Agric. Sci., Agric. Eng. Dep. Approved for publication as Journal Series No. R-03501 by the Florida Agric. Exp. Stn. Partial funding from IBSNAT project of USAID through the Univ. of Hawaii, contract no. AID/DAN-4054-A-00-7081-00. Received 21 May 1993. *Corresponding author.

Published in Agron. J. 86:332–337 (1994).

Abbreviations: DSSAT, Decision Support System for Agrotechnology Transfer; IBSNAT, International Benchmark Sites Network for Agrotechnology Transfer; K, kilobyte; PAR, photosynthetically active radiation; ver., version.

Table 1. Examples of weather data files using the IBSNAT formats.

Version 2.1

```
        0         1         2         3         4         5
Line    0123456789012345678901234567890123456789012345678901234 5

1       UFGA  29.63   82.37 11.90   1.00  XLAT,XLONG,PARFAC,PARDAT†
2
3       SITE YR DOY  SRAD  TMAX  TMIN  RAIN    PAR‡
4       UFGA 88   1  9.31  23.3  10.3   0.0  18.62
5       UFGA 88   2 11.09  19.0  16.9   5.2  21.27
6       UFGA 88   3  3.13  23.9  15.6   0.0  11.65
```

Version 3.0

```
        0         1         2         3         4         5
Line    0123456789012345678901234567890123456789012345678901234 5

1       *WEATHER : GAINESVILLE, FLORIDA, U.S.A.
2
3       @ INSI      LAT     LONG  ELEV   TAV   AMP REFHT WNDHT†
4         UFGA   29.630  -82.370    10  20.9   7.4   1.5   2.0
5
6       @YRDAY SRAD  TMAX  TMIN  RAIN  DEWP  WIND   PAR‡
9       88001   9.3  23.3  10.3   0.0  11.3 165.0  18.6
10      88002  11.1  19.0  16.9   5.2  15.2  53.2  21.3
11      88003   3.1  23.9  15.6   0.0  14.5 201.4  11.7
```

† Header abbreviations: AMP = average annual temperature range (°C); DOY = 3-digit day of year; ELEV = weather station elevation (m); LAT = XLAT = weather station latitude (°); LONG = XLONG = weather station longitude (°); PARDAT = 0–1 flag to indicate presence of PAR data in file; PARFAC = conversion factor from SRAD to PAR (langley/mol); REFHT = reference height for meteorological instruments (m); SITE = INSI = 4-letter institution and site code; TAV = average annual temperature (°C); WNDHT = reference height for anemometer (m); YR = 2-digit year; YRDAY = 5-digit year and day of year.

‡ Variable abbreviations: DEWP = daily dew point temperature (°C) (optional); PAR = daily photosynthetically active radiation (mol m^{-2} d^{-1}) (optional); RAIN = daily rainfall (mm); SRAD = daily solar radiation (MJ m^{-2} d^{-1}); TMAX = maximum daily temperature (°C); TMIN = minimum daily temperature (°C); WIND = daily wind run (km d^{-1}) (optional).

computer with DOS ver. 3.1 or later and requires at least 280K of available conventional memory when working with five weather variables. An extra 12K of memory are required for each additional variable. WeatherMan works best using a math coprocessor and at least 300K of available expanded memory since it performs faster and requires 50K less available conventional memory. A hard disk is recommended. Stored weather data files occupy ≈ 14K per year for five variables. Standard video drivers are automatically detected, and WeatherMan includes several printer drivers for graphical output (Epson MX, Epson FX, Toshiba, HP LaserJet, and HP InkJet), as well as plotter and file output drivers (HPGL and Postscript).

Overview of Functions

The WeatherMan's main menu items are: **File**, **Station**, **Import/Export**, **Generate**, **Analyze**, **Options**, **Quit**. The **File** menu accesses a user-selectable text editor for data entry and correction, accesses the operating system (DOS), and allows the current weather data directory to be changed. A new weather station is selected from the **Station** menu. The **Import/Export** menu handles the conversion of file formats and units when importing and exporting weather data into or from a storage data file. Many file formats can be accommodated, including the standard IBSNAT ver. 2.1 and 3.0 files. WeatherMan checks for and flags format or range errors on import. On export, data flagged as missing or erroneous can be replaced or approximated using several methods. The **Generate** menu permits generation of synthetic sequences of solar radiation, maximum and minimum temperature, rainfall, and photosynthetically active radiation for any duration. The **Analyze** menu includes the computation of summary statistics and the ability to display the results using tables or graphs. The **Options** menu allows the user to customize the default setup. The user can leave the program using the **Quit** menu or the **File-Exit** submenu.

File Operations

File operations are grouped under the **File** menu, which gives access to an editor, DOS functions, and additional help. The **Edit** menu item accesses a text editor so that data files can be viewed and edited. Under DSSAT ver. 3.0, the default DSSAT editor is used. If WeatherMan is used as a stand-alone program, a modified Turbo Pascal editor called TVEDIT2 can be provided as the default editor (Borland, 1993). The user can use any editor by changing the default path and editor name under the Options menu. The **Change Dir** menu item will change to another data directory to access other weather data and archived files. The **Dos Shell** menu item allows one to leave the WeatherMan program temporarily without removing it from memory, which is useful for performing DOS functions like renaming, deleting or copying files. The **About** menu item displays introductory information on the WeatherMan. Additional information about the program can be accessed by pressing F1 from the introductory dialog box. The **Exit** menu item is used to permanently exit the WeatherMan program.

Selecting a Weather Station

The **Station** menu allows selection of a weather station and the entry of general station information. On identifying a station, archive and climate files are automatically created based on the station name (here represented in italics as *station*). The archived file (*station*.WTD) is an internal ASCII file that has a standard format and fixed set of units that mirrors the imported raw data. Although we could use random access files (as did Robbins, 1993), prior user response with DSSAT ver. 2.1 database files was very negative. We gave higher priority to user access of the ASCII archived file than the increased speed that results from random access.

Weather data are imported into and exported from the archived file, and the file can also be used for long-term storage of weather data. The climate file (*station*.CLI) contains site information, weather generator parameters, range-check values, and summary statistics for the station. It is automatically updated after each **Import** operation and is an alternative to self-describing files (Robbins, 1993).

Since most operations in WeatherMan require the selection of a Weather station, this is normally the first menu used. A station is selected from a list of all archived (*station*.WTD) files in the current directory. Files in other directories can be displayed by selecting the appropriate directory under the **File** menu. When a new weather station is selected, the user is automatically prompted for general information regarding the new station. This information can be subsequently edited. Of this information, only latitude is absolutely essential, since it is used to verify the radiation data. For a new station, the user can choose to manually enter the monthly means of solar radiation, maximum temperature, minimum temperature, rainfall total, and rainfall frequency. These data are usually available from published secondary sources of climate data (NOAA, 1974, 1977; Samani and Hargreaves, 1989). Alternatively, these values can be computed by the Weatherman using the available daily data in the archived file. The user is warned if <5 yr of good quality daily data are currently available. Monthly means are stored in the climate file for the current station. The monthly means are used by the WeatherMan for filling in data and generating weather data sequences. These options are disabled when there are no available monthly means.

Importing and Exporting Data

The **Import/Export** menu performs all the necessary data manipulation for inserting data into the archived file (**Import**) and extracting it to create other files (**Export**). Both the **Import** and **Export** menu items use a format definition file (*.FMT) to translate the format and units of the data between the specified input or output file and the archived file. Currently only data in columns are permitted. Processing of other format types (row, comma delimited) could easily be developed. The user can customize the column format for up to 12 variables (any order, any units).

The simplest **Import-Export** function is to translate a file from one format to another. This feature uses a temporary archived file and sequentially imports then exports with checking and data-fill options disabled. Other **Import** or **Export** options use a permanently archived file and refer to its corresponding climate file for the checking and data-fill functions.

The **Import** menu item can be used to import a single file or multiple files. The first is simpler; the second builds a sorted list of files and formats that are sequentially imported. The multiple-file feature is useful when the weather variables are stored in different files with different formats, or for a group of files with the same format. The list of files can be constructed easily and rapidly, permitting the user to import all the available weather data for a weather station in a single operation.

Variables that have errors or are suspect are automatically flagged on import. The error types, with their explanation and code, are listed in Table 2. The error types are based on a subset of those used by the National Climatic Data Center (Reek et al., 1991). A value is flagged if it is less than some minimum, greater than some maximum, or exceeds a specified rate-of-change from one day to the next. When a variable is flagged during import, its value remains unaltered. The extreme values used to check each variable can be easily modified from an **Import** menu item. The radiation extremes are seasonal, since they are expressed in terms of percent of extraterrestrial radiation. On import, a lowercase letter is used to flag each error. On export, if the missing or erroneous value is replaced or approximated, the flag is converted to uppercase to indicate that the original value was modified.

Conversion errors normally result from an incorrect format or a nonnumeric character. This type of error results in a missing value (−99.0). If specified by the user, a nonnumeric value can be translated into a numeric value: e.g., 'TRACE' for rainfall can be converted into 0.00 mm rather than a missing value. At the end of the import process, a summary report is given indicating the quantity and quality of data in the archived file. The **Import** options include a default for the format name (e.g., IBSNAT), a switch to enable/disable range-checking, and a choice to prompt for the translation of nonnumeric characters in the data.

Table 2. Explanation of error codes used to flag suspect or erroneous data, and examples of raw weather data, archived, and exported files including these codes. Errors are flagged with lower case codes on import into the archived file. On export, if the flagged data are filled, the flagged codes are converted to upper case. File formats were adjusted for ease of comparison.

Class	Description	Import code	Filled export code
Range check	Above maximum	a	A
Range check	Below minimum	b	B
Range check	Above rate of change	r	R
Conversion	Missing value	n	N
Conversion	Format error	e	E

File	SRAD	TMAX	TMIN	RAIN	PAR
	Variables†				
Imported	62.23	23.3	−25.3	0.0	??.??
	11.09	8.3	16.9		21.30
	3.10	23.9	15.6	TRACE	11.70
Archived	62.2a	23.3	−25.3b	0.0	−99.0e
	11.1	8.3r	16.9	−99.0n	21.3
	3.1	23.9	15.6	0.0e	11.7
Exported	9.30A	23.3	10.3B	0.0	18.60E
	11.10	19.0R	16.9	5.2N	21.30
	3.10	23.9	15.6	0.0E	11.70

† SRAD, daily solar radiation (MJ m^{-2} d^{-1}); TMAX and TMIN, maximum and minimum daily temperature (°C); RAIN, daily rainfall (mm); PAR, daily photosynthetically active radiation (mol m^{-2} d^{-1}).

The **Export** menu item can be used to export a single file or yearly files. For the yearly file option, the names of the export files are constructed automatically, using either the IBSNAT ver. 2.1 or 3.0 naming convention. The files can easily be renamed using the DOS RENAME command. The export options include a default choice of format name (e.g., IBSNAT), two file name conventions for yearly files (IBSNAT ver. 2.1 or 3.0), choices for including header information, and various options for data-fill and error flag handling. Data-fill for missing data, range errors, and missing dates can be enabled or disabled, and there is a choice to export error flags. If the data-fill option is selected, there are several choices for the method to be used.

There are two generic data-fill methods used for all weather variables. The first generic method is to generate all missing data with the WGEN or SIMMETEO weather generators. The second method uses the monthly means from the climate file. The generators only fill in solar radiation, maximum temperature, minimum temperature, rainfall, and PAR. Data-fill using the monthly means applies to all variables except rainfall, since a constant drizzle would cause severe problems with any water balance. A simple stochastic generator is used for rainfall. There are additional data-fill methods for solar radiation and short periods of missing data. Solar radiation can be estimated from sunshine hours and extraterrestrial radiation (Doorenbos and Pruitt, 1977), using coefficients that are entered as general site information. Short periods (<7 d) can be filled using a 10-d running mean, but for longer data gaps the generic data-fill methods are automatically invoked.

An illustration of the codes is given in Table 2, showing the use of these codes in the archived and exported files. Prior to importing the original raw data file into the archived file, the file had two or three errors per line. On importing into the archived file, the alphabetic errors were changed, while the other erroneous data were only flagged. The export file was created with all the data-fill options enabled, thus the errors were filled and the error flags were converted to uppercase codes.

Generating Weather Data

The **Generate** menu allows estimation of the weather generation parameters and subsequent generation of daily weather data. The weather generators used are adaptations of WGEN (Richardson and Wright, 1984) and SIMMETEO (Geng et al., 1986; Geng and Auburn, 1986; Geng et al., 1988). The SIMMETEO generator is embodied in the WGEN generator, but uses a different input section. The resulting WGEN/SIMMETEO code is a single program that is identical to the FORTRAN version currently used internally with the IBSNAT ver. 3.0 crop models. Currently, only solar radiation, maximum temperature, minimum temperature, rainfall, and PAR are generated. Future versions could include wind speed and vapor pressure.

The IBSNAT ver. 3.0 modification of WGEN/SIMMETEO now uses monthly input parameters for all variables. Daily values are computed internally, using linear interpolation. The modified SIMMETEO model uses monthly climate means and regression equations (Geng et al., 1986; Geng and Auburn, 1986; Pickering et al., 1988) to compute the standard deviations. We found that using standard deviations is more reliable than using coefficients of variations to estimate the monthly standard deviations. A seasonally increasing mean and decreasing coefficient of variation can produce an odd seasonal effect on standard deviation. It is also easy to prevent impossible (negative) predicted standard deviations.

The parameters for WGEN or SIMMETEO can be computed separately or together, using all the data or a particular time period in the archived file. The computed monthly parameters are recorded in the climate file. Estimating the SIMMETEO parameters is equivalent to calculating the monthly means from the **Station** menu. If the monthly means in the climate file are from a longer and more reliable record than the daily data, the user should not estimate SIMMETEO's parameters using the daily data, since the long-term means will be overwritten. Estimating generator parameters is a reasonable option if there are sufficient reliable data in the archived file or if there are no available climate data. The user is warned if there are <5 yr of reliable data in the archived daily data file.

The generated data are output to a generated archived file (*station*_GEN.WTD). The default action is to use the time period of the archived file for the generated data, although any time period can be specified. Matching the time periods facilitates comparison of observed and generated data. A random number seed is reset from the system clock each time the generator is used, but any random number can be specified by the user. Often the same number is desired to create repeatable sequences of generated weather data.

Analyzing Weather Data

The **Analyze** menu calculates and presents summary statistics for archived weather data in the form of tables and graphs. The analysis can be performed on raw, filled, or generated data. **Analyze** also offers range-check and data-fill functions similar to those normally done automatically on import or export. The range-checking process is useful when the file import was done with incorrect range check values or when the range checking option was turned off. Re-checking is also useful in defining reasonable range-check values for a weather station by iteratively setting the range-check values and appraising how many values are flagged. The data-fill option creates a filled archived file (*station*_FIL.WTD) that can be analyzed and compared with the raw data to check the data-fill algorithms.

The statistics option provides algorithms for summarizing archived data in various ways. Statistics are output to summary files that can be viewed, printed, or graphed. There are four types of statistics: moments, percentiles, distribution, and time structure. The moments include the means, standard deviations, and skewness coefficients. The percentiles are the 0, 25, 50, 75, and 100% quantiles. The distribution statistics option includes both histograms and cumulative probabilities. The time structure option includes autocorrelograms for all variables except rainfall and conditional probabilities for rainfall. All statistics, except autocorrelograms and rainfall conditional probabilities, are automatically computed for wet, dry and both days. The autocorrelograms and rainfall conditional probabilities use the complete time series thus do not distinguish between wet and dry days. Three statistics groupings can be selected: monthly summary, monthly time series, and yearly time series. An overall summary (normals) is automatically performed with the monthly summary.

The graphics capabilities include plotting both the daily data in the archived files and the statistics summary files. Time-series graphs, box plots, histograms (for probability distributions and conditional rainfall probabilities), cumulative probability distribution plots, and autocorrelograms are available. The time-series graphs can be used to plot either daily data or summary statistics versus time. There is considerable flexibility in choosing the weather station, grouping, variables, and wet state (i.e., wet days, dry days, or all days), and the time period of data to be plotted. Up to six plots per graph can be defined and plotted.

Two examples of WeatherMan graphs are given in Fig. 1 and 2. Figure 1 is a simple illustration of a daily data plot (in this case, maximum and minimum temperatures versus time). This kind of plot is useful for visually screening data for obvious errors (e.g., data points that remain constant). Figure 2 is an example of a plot of the moments that are computed using the **Statistics** menu item. The plot compares the mean monthly maximum and minimum

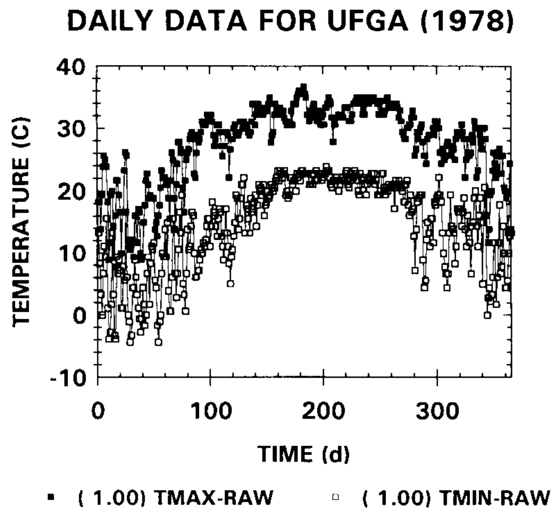

Fig. 1. Plot of 1978 daily maximum and minimum temperature (°C) versus time (d) for Gainesville, FL (UFGA). Multipliers for the *y*-axis are given in parentheses in the legends. Enhanced for publication.

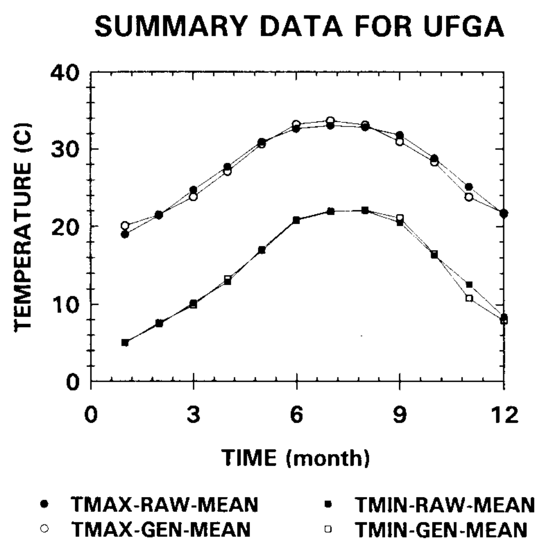

Fig. 2. Plot of overall mean monthly maximum and minimum temperature (°C) versus time (months), using raw and generated data for Gainesville, FL (UFGA). Enhanced for publication.

temperatures from raw and generated files. This feature can be used to visually verify and validate the generation and data-fill algorithms.

Selecting Options

The **Options** menu allows the user to customize the default setup. The display mode is automatically detected, but can be changed if another valid choice is desired. The video mode is best left in autodetect mode unless the program has difficulty selecting the correct mode and a manual choice gives better screen appearance. Liquid crystal displays (LCDs) or plasma displays used on portable computers sometimes look better in black and white mode than in the automatically detected color mode. Background and foreground colors used in the WeatherMan can also be changed. Directories for the daily weather data, climate files, graphics program, graphics output, and file editor can be changed. These directories can also be obtained from the DSSAT profile file, which is available if the program is being run under DSSAT ver. 3.0. Summary, generated, and filled archived files are temporary files that are normally discarded on terminating WeatherMan. This default action can be modified to automatically keep all temporary files or to prompt the user to keep or discard each file. The graphics program can be customized by changing the format (e.g., grid, ticks), colors, and output drivers as mentioned in the above Specifications section. The changes in the **Options** menu can be permanently updated if desired. Updating options also saves the current options chosen in the **Import**, **Export**, **Data-Fill**, and **Summary Statistics** menus.

AVAILABILITY AND DOCUMENTATION

The WeatherMan program can be obtained from the IBSNAT project headquarters or from the development group at the following addresses: Dr. Gordon Tsjui, IBSNAT Project, University of Hawaii, 25000 Dole St., 22 Krauss Hall, Honolulu, Hawaii 96822; Dr. James W. Jones, Department of Agricultural Engineering, University of Florida, Gainesville, FL 32611. Interested persons should send a letter of request and a single 3.5- or 5.25-inch high-density diskette. Included with the program is the WeatherMan manual, which describes its features and the installation procedure, and gives detailed information on each function.

REFERENCES

Borland. 1993. Turbo Pascal. Version 7. Borland Int., Scotts Valley, CA.

Brown, P.W., and M. Yitayew. 1988. Near-real time weather information for irrigation management in Arizona. p. 708–715. *In* D.R. Hay (ed.) Proc. Conf. on Planning Now for Irrigation and Drainage in the 21st Century, Lincoln, NE. 18–21 July. Irrig. Drain. Div., ASCE, New York.

Carlson, J.D., and H.L. Russell. 1988. Relational database management of agricultural weather data in Michigan. p. 475–480. *In* F.S. Zazueta and A.B. Bottcher (ed.) Proc. Int. Conf. on Computers in Agricultural Extension Programs, 2nd, Orlando, FL. 10–11 Feb. Florida Coop. Ext. Serv., IFAS, Univ. of Florida, Gainesville.

Doorenbos, J., and W.O. Pruitt. 1977. Guidelines for predicting crop water requirements. 2nd ed. FAO Irrig. and Drain. Paper 24. FAO, Rome.

Geng, S., F.W.T. Penning de Vries, and I. Supit. 1986. A simple method for generating daily rainfall data. Agric. For. Meteorol. 36:363–376.

Geng, S., J.S. Auburn, E. Brandstetter, and B. Li. 1988. A program to simulate meteorological variables: Documentation for SIMMETEO. Agronomy Progress Rep. 204. Dep. of Agronomy and Range Science, Univ. of California, Davis, CA.

Geng, S., and J.S. Auburn. 1986. Weather simulation models based on summaries of long-term data. p. 237–254. *In* Int. Symp. on Impact of Weather Parameters on the Growth and Yield of Rice. 7–10 Apr. IRRI, Manila, Philippines.

Hubbard, K.G., N.J. Rosenberg, and D.C. Nielsen. 1983. Automated weather data network for agriculture. Water Resour. Plan. Manage. 109(3):213–222.

IBSNAT. 1989. Decision support system for agrotechnology transfer. Version 2.1. User's guide. Dep. of Soil Science, Univ. of Hawaii, Honolulu.

Jones, J.W., L.A. Hunt, G. Hoogenboom, U. Singh, D.C. Godwin, N.B. Pickering et al. 1993. Input and output file structures for crop simulation models in DSSAT V3.0. Dep. of Agric. Engineering, Rogers Hall, Univ. of Florida, Gainesville.

National Oceanic and Atmospheric Administration. 1974. Climate of

the states. Water Information Center, NOAA, U.S. Dep. of Commerce, Port Washington, NY.
National Oceanic and Atmospheric Administration. 1977. Climatography of the United States No. 60: Climate of the states. Environmental Data Service, NOAA, U.S. Dep. of Commerce, Asheville, NC.
Pickering, N.B., J.R. Stedinger, and D.A. Haith. 1988. Weather input for nonpoint-source pollution models. J. Irrig. Drain. Eng. 114(4):674-690.
Quinn-Curtis. 1993. Science and engineering tools for Turbo Pascal. Quinn-Curtis, Needham, MA.
Reek, T., S.R. Doty, and T.W. Owen. 1991. The validation of historical daily climate data. Earth Sys. Monit. 2(2):3-4.
Reinke, B.C., and S.E. Taylor. 1991. Historical climate data management for agriculture: A microcomputer-based methodology. Comput. Electron. Agric. 5(4):297-304.
Richardson, C.W., and D.A. Wright. 1984. WGEN: A model for generating daily weather variables. ARS-8. USDA-ARS, Washington, DC.
Robbins, K.D. 1993. Climate data file management for agricultural modeling. Appl. Eng. Agric. 9(1):49-53.
Samani, Z.A., and G.H. Hargreaves. 1989. Applications of a climatic data base for Africa. Comput. Electron. Agric. 3:317-325.
Snyder, R.L., W.O. Pruitt, and A. Dong. 1985. An automatic weather station network for estimation of evapotranspiration. p. 132-142. *In* Int. Conf. on Crop Water Requirements, Versailles, France. 11-14. Sept. INRA, Paris.

The ALFALFA CATALOG Software Package

M. S. Townsend, J. A. Henning,* and C. G. Currier

ABSTRACT

Due to modern plant breeding methods, agricultural producers have many cultivars available for many different species. Consequently, it is often difficult to recommend a cultivar for a particular growing area. A list of alfalfa cultivars, germplasms, and breeding lines available was published. However, due to the large number of entries in these publications finding pertinent information about a cultivar, breeding line, or germplasm was tedious. The objectives of this project were to (i) develop a computer program to access the alfalfa information in the original database, and (ii) update the database to include those alfalfa cultivars, breeding lines, and germplasms released through late 1992. A computer program was written using Microsoft QuickBasic, ver. 4.5. The original alfalfa database was converted to ASCII format. The resulting software package is entitled the ALFALFA CATALOG ver. 1.0. Three program files and four data files comprise the ALFALFA CATALOG software package. Users may rapidly search the database and retrieve entries by cultivar name, experimental designation, or germplasm. We also wrote a routine to print a list of all cultivars or germplasms that have a specific combination of traits. These search capabilities will allow plant breeders, extension agents, and consultants rapid access to pertinent alfalfa data. Currently, the ALFALFA CATALOG has 752 entries for cultivars and breeding lines, and 144 entries for germplasms. The database will be updated yearly. In its present form, the ALFALFA CATALOG is probably the most complete compilation of alfalfa cultivars, breeding lines, and germplasms available.

THE IMPLEMENTATION of superior plant breeding techniques has allowed plant breeders to rapidly develop improved plant populations for crop production. An unfortunate consequence of numerous cultivars is the difficulty encountered when one must identify suitable cultivars for different production areas. Agricultural scientists, extension personnel, and consultants often recommend cultivars for specific growing areas. Much time is spent reviewing research reports and analyzing data to make such recommendations. Plant breeders may need to obtain population characteristics for cultivars, breeding lines, or germplasms suited to a particular geographic region. This can be a time-consuming task given the amount of plant genetic resources available.

Hannaway et al. (1992) released a computerized database called ACE, which allows producers and consultants to find alfalfa (*Medicago sativa* L.) cultivars based on search criteria. This computerized database contains ≈450 alfalfa cultivars, and information related to seed certification, cultural practices, diseases, and other production topics. Although a very useful program, ACE is somewhat limited in that it does not contain all cultivars that have been released, nor does it contain alfalfa breeding lines and germplasms that are available. Also, ACE appears to be oriented to assist consultants and extension personnel with alfalfa varietal selection.

New Mexico State University compiled all of the published alfalfa cultivars, breeding lines, and germplasms released prior to 1983 (Miller and Melton, 1983). This compilation and the 1989 update (Melton et al., 1989) provided valuable information to anyone interested in alfalfa genetic resources. Information on 640 cultivars and breeding lines, and 144 germplasms were included in these publications. Because of the large size of these databases, retrieving information was time-consuming.

A solution to enhancing the availability of alfalfa information in the New Mexico publications was to develop a computerized database. The objectives of this project were to (i) write a computer program to access the information in the New Mexico publications and (ii) update the databases to include alfalfa cultivars, breeding lines, and germplasms released through late 1992.

PROGRAM DESCRIPTION

Information for the databases was obtained from North American Alfalfa Improvement Conference reports, *Crop Science* registrations, and summaries from applications to the National Alfalfa Variety Review Board. The original databases were entered onto computer using PC-FILE+ (ver. 2.0, 1988; ButtonWare, Bellevue, WA). The databases were converted to ASCII format for use with the ALFALFA CATALOG software package. There are

Dep. of Agronomy and Horticulture, New Mexico State Univ., Las Cruces, NM 88003. Support by the New Mexico Agric. Exp. Stn. Received 14 June 1993. *Corresponding author.

Published in Agron. J. 86:337-339 (1994).

Abbreviations: K, kilobyte; ver., version.